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Biological Effects of Electric Fields

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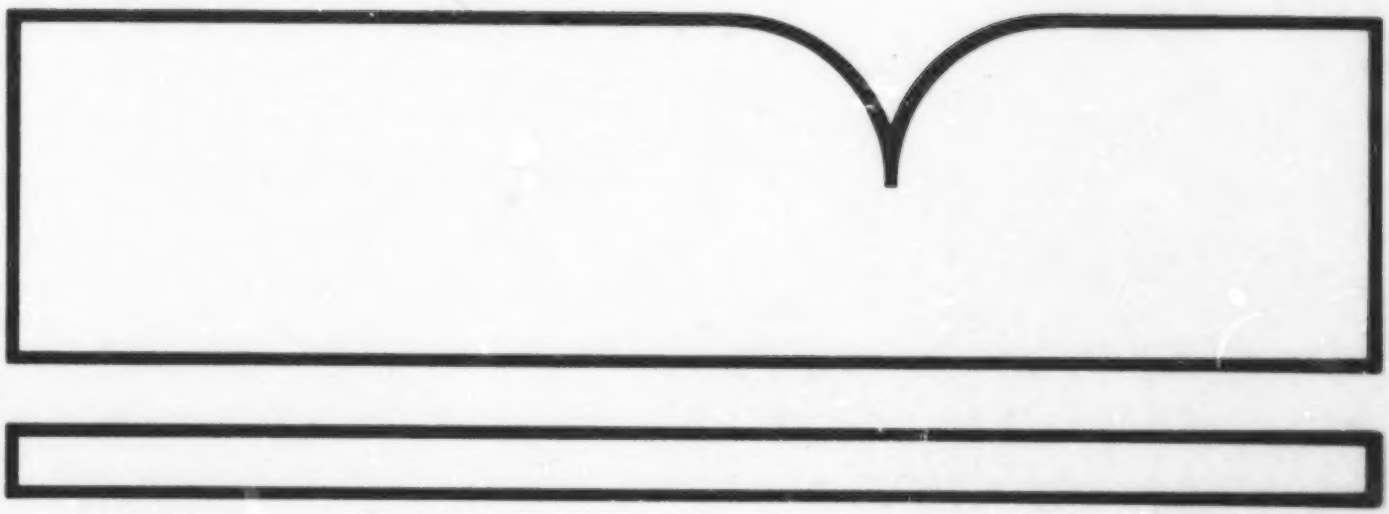

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BIOLOGICAL EFFECTS OF ELECTRIC FIELDS

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ABSTRACT

Extremely low-frequency (ELF) electric and magnetic fields, many times above ambient levels, occur in the vicinity of existing and proposed energy generating, storage and transmission systems. Concern over possible deleterious health effects due to exposure to these electric fields was first expressed in the late 1960s and early 1970s. In an early Soviet study, a variety of neurological symptoms, including headaches, excitability, fatigue, and nausea, were reported in workers at ultra-high-voltage (>345 kV) switchyard stations. Although it is not possible to conclude that the reported functional changes resulted from exposure to the electromagnetic fields, the research findings led to additional research in the USSR and throughout the rest of the world. Numerous studies were initiated in a wide range of investigations to assess the potential biological consequences of exposure to static and ELF electromagnetic radiation. These studies included epidemiological investigations of people exposed, both occupationally and nonoccupationally, to electric fields, as well as experiments on laboratory animals. This paper represents a cursory overview of research concerned with the biological consequences of exposure to extremely-low-frequency radiation. It summarizes epidemiological and clinical studies conducted to date and a somewhat more extensive examination of results of studies using experimental animals. In an attempt to help the reader evaluate and interpret those results, a discusison of current concepts on possible mechanisms and future directions of research are presented.

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Biological Effects of Electric Fields

INTRODUCTION

Extremely low-frequency (ELF) electric and magnetic fields, many times above ambient levels, occur in the vicinity of existing and proposed energy generating, storage and transmission systems. Concern over possible deleterious health effects due to exposure to these electric fields was first expressed in the late 1960s and early 1970s. In an early Soviet study, a variety of neurological symptoms, including headaches, excitability, fatigue, and nausea, were reported in workers at ultra-high-voltage (>345 kV) switchyard stations (Asanova and Rakov, 1966; Korobkova et al., 1972). Although it is not possible to conclude that the reported functional changes resulted from exposure to the electromagnetic fields, the research findings led to additional research in the USSR and throughout the rest of the world. Numerous studies were initiated in a wide range of investigations to assess the potential biological consequences of exposure to static and ELF electromagnetic radiation (e.g, Singewald et al., 1973; deLorge and Marr, 1974; Kouwenhoven et al., 1967; Knickerbocker et al., 1967; Graves et al., 1979; Knave et al., 1979; Cerretelli et al., 1979; Phillips et al., 1979a, 1981). These studies included epidemiological investigations of people exposed, both occupationally and nonoccupationally, to electric fields, as well as experiments on laboratory animals.

Several major symposia and reviews of the literature have been published in recent years (AIBS, 1985; Anderson and Phillips, 1984; Bridges, 1975a, b, 1978; Sheppard and Eisenbud, 1977; National Academy of Sciences, 1977; Michaelson, 1979; Phillips et al., 1979b; IITRI/EPRI, 1979; Males and

Norris, 1980; WHO, 1984; Lee et al., 1982; Sheppard 1983). These reviews address a broad range of research interests and represent a considerable volume of literature, particularly with regard to experimental animal studies.

This paper represents a cursory overview of research concerned with the biological consequences of exposure to extremely-low-frequency radiation. It summarizes epidemiological and clinical studies conducted to date and a somewhat more extensive examination of results of studies using experimental animals. In an attempt to help the reader evaluate and interpret those results, a discusison of current concepts on possible mechanisms and future directions of research are presented.

EPIDEMIOLOGICAL STUDIES

It is difficult to obtain quantitative, unbiased data which can be reliably interpreted from epidemiological studies. Two major problems have plagued many of the human exposure studies to date: 1) failure to obtain quantitative data on the level and duration of exposure, and 2) failure to include an appropriate control group that is comparable in all respects to the exposed group, except for exposure to the electromagnetic field. While this does not necessarily invalidate the results of such studies, it is important to be aware of these potential problems when evaluating the results.

The earliest investigations of human exposure to power-frequency electric fields were conducted in the Soviet Union in the early 1960s (Asanova and Rakov, 1966; Korobkova et al., 1972). These surveys of workers

in high-voltage switchyards indicated a variety of symptoms in the cardiovascular, digestive and central nervous systems subsequent to prolonged exposure of switchyard workers to electric fields (up to 26 kV/m). The disturbances noted in these studies were quite subjective. More recent work in the USSR has raised some questions as to the cause of the observed effects. It has been suggested that the observed effects might be the result of exposure to microshocks or kerosene vapor rather than exposure to electric fields (Danilin et al., 1969; Krivova, 1968; Savin et al., 1978; Bourgsdorf, 1980).

Results from the earliest comparable studies in the United States failed to confirm those of the USSR studies. Kouwenhoven et al. (1967) and Singewald et al. (1973) studied 10 linemen exposed over a 4-year period to unperturbed fields of up to 25 kV/m and observed no correlation between exposure and the health of the subjects. This study, however, included only a small number of subjects, and descriptions of the experimental protocol and results are incomplete.

Studies of agricultural workers exposed to electric fields have been conducted in both the USSR and the United States. Dumansky et al. (1977) found no effects in farmers exposed to ELF fields of 12 kV/m for 1.5 hours per day, but fatigue and a mild physiological effects were reported by workers exposed in similar environments to 16 kV/m. Eighteen farmers in Ohio working around 765-kV transmission lines reported no adverse health effects (Busby et al., 1974). Similarly, a study of 70 families living and working close to 200- and 400-kV lines in France revealed no problems attributable to electric-field exposure (Strumza, 1970).

Recent health surveys of occupationally exposed male workers include two especially thorough studies: Stoops et al. (1979), in Canada, and Knave et al. (1979), in Sweden. Both groups examined a wide range of biological variables and reported no significant health effects in nervous system function, blood chemistry, cardiovascular function or general physical condition. Knave and coworkers reported differences between exposed and unexposed persons in scores obtained on psychological questionnaires (the exposed group scored better), and in fertility (fewer offspring and a lower percentage of male infants fathered by exposed workers). These differences, however, could not be ascribed solely to electric field exposure. The authors suggested that the differences might be due to variations in the level of education or other differences between the two populations.

Another study in Sweden (Nordstrom et al., 1981), describes preliminary work in which increased frequency of chromosome breakage was seen in a few workers exposed to 400 kV. In additional work, congenital deformities were found in 10% of 119 children of substation workers, whereas only 2.7% of unexposed workers showed such deformities (Nordstrom et al., 1983). Analyses of these data raise major questions in the interpretation of the results because the highest percentage of abnormal progeny appears to be related to job type rather than to level of exposure.

Recently, there has been a great deal of concern that exposure to ELF magnetic fields may be associated with the incidence of cancer. Wertheimer and Leeper (1979) have reported an increased incidence of leukemia among children in Denver, CO whose homes had electrical wiring configurations

suggestive of high-current flow. Presumably, these high-current configurations resulted in increased levels of magnetic fields in the homes. In a later study, Wertheimer and Leeper (1982) extended their research and found similar results in adults. A similar study by Fulton et al. (1980) in Rhode Island found no correlation between childhood leukemia and configuration of wiring in the homes. From a recent study in Sweden, Tomenius et al. (1983) reports increased cancer rates in children whose homes had magnetic fields (50 Hz) greater than 3 mgauss.

Recent examinations of deaths in Washington State (Milham, 1982), Los Angeles (Wright et al., 1982), England and Wales (McDowall, 1983), London (Coleman et al., 1983), and New Zealand (Pearce et al., 1985) show an association between deaths due to cancer and occupations in electrical environments. Because of the limitations of such studies, one cannot safely interpret the meaning of these findings. However, the clustering of such data from various mortality records strongly suggests that research is needed to investigate the potential relationship of very weak electromagnetic fields and cancer.

In summary, few physiological or psychological effects have been credibly related to electric-field exposure. Documentation of such effects, when reported, is often questionable for the following reasons:

- Monitoring of symptomatology is quite subjective and is frequently not well-defined.
- Quantitative evaluation of effects is either not performed or is not clearly described.
- Control populations are ill-matched with exposed groups or are nonexistent.
- Electric and magnetic fields have been confounded by secondary factors (e.g., microshocks).

- Duration of observations is often limited to short time periods.
- Exposure levels vary widely and are not documented, making it difficult to accurately estimate the magnitude and duration of exposure.
- Many of the earlier studies have insufficient numbers of subjects to establish the statistical significance of putative effects.

ANIMAL EXPERIMENTS

Although the interaction of humans with electric fields is of prime importance and concern, many areas of biological investigation are more efficiently and appropriately conducted using various other animal species. Experiments have been performed using rodents (rats and mice), primarily, but a wide variety of other subjects, including insects, birds, dogs, swine, and non-human primates, have also been used. A broad range of exposure-levels have been employed, from a few volts/meter to more than 100 kV/m. An equally large number of biological endpoints have been examined for evidence of possible electric-field effects.

Because we cannot discuss all of the large number of animal experiments performed, we will limit our review to studies concerning exposure to 60-Hz electric fields. The summaries are arranged according to the biological systems involved: behavior, biological rhythms, nervous system, endocrinology, bone growth and repair, cardiovascular system and blood chemistry, immunology and infectivity, fertility and reproduction, growth and development, mortality and pathology, cellular and membrane studies, and mutagenesis. These summaries show that, in most areas, some studies showed effects of exposure, and other studies showed no effects. There is general concurrence among scientists that exposure to 60-Hz electric fields produces biological effects;

however, there is an evident lack of unanimity as to whether those effects constitute a hazard. A brief synposis and discussion of each area follows.

Behavior. Among the most sensitive measures of insult to a biological system are tests which determine modifications in the behavioral patterns of animals. This sensitivity is especially valuable in studying environmental agents of relatively low toxicity.

Animals detect electric fields at low field strengths. The threshold of detection reported by Stern et al. (1983) is between 4 and 10 kV/m in rats. Approximately 50% of exposed mice in a study by Rosenberg et al. (1983) responded to a field of 35 kV/m. Graves et al. (1978) reported that pigeons perceive electric fields at 32 kV/m. Pigs responded at about 30-35 kV/m (Kaune et al., 1978). Some indications of exposure-influenced activity were evident in several of those species at even lower field strengths. Moos' data (1964) suggest increased activity ($p < 0.05$ in two of five groups) in mice during the night, at field strengths of only 1.2 kV/m. Graves (1977), Rosenberg et al. (1983) and Hjeresen et al. (1980) have reported an orientation response, or increased activity at initial exposure, in rats and mice at 25-35 kV/m. This increased activity was transitory and disappeared within a relatively short period of time. In a well-documented study by Greenberg et al. (1979, 1981), increased activity was observed in honey bees in hives exposed to 4.2 kV/m. Exposed birds showed a behavior pattern opposite to that of other animals: activity in chickens was suppressed during exposure to 26 or 40 kV/m (Graves et al., 1978; Bankoske et al., 1976). At higher field strengths (up to 80 kV/m), no effect was observed on their activity or general behavior (Graves et al., 1978; Bankoske et al., 1976).

Some interesting results have been observed in the preference/avoidance behavior of rats for remaining in or out of the electric field. At 100 V/m, no effect of exposure was evident, either in preference behavior or temporal discrimination (deLorge and Marr, 1974). However, at 25 kV/m, rats preferred to spend their inactive period in the field, while at 75-100 kV/m they avoided exposure (Hjeresen et al., 1980). Swine (Hjeresen et al., 1982) remained out of the field (30 kV/m) at night but demonstrated no observable behavioral changes (e.g., activity, reaction to novelty or startle response).

Most of the behavioral work with nonhuman primates has been performed at very low field strenghts (7-100 V/m) (deLorge 1972, 1973). Gavalas (1970) and Gavalas-Medici et al. (1976) observed changes in interresponse time with exposure, but no other effects were seen. At much higher field strength (30 kV/m), Feldstone et al. (1980) reported anecdotal information suggesting minor behavioral changes in exposed animals that appear to be related to their perception of the field.

In summary, the behavioral tests which most frequently showed an effect of exposure were those relating to detection of the field or to activity. Most other behaviors did not change with electric-field exposure at field strengths up to 100 kV/m.

Biological Rhythms. Few investigations have been conducted to examine the effects of 50- to 60-Hz electric fields on natural biological rhythms. Ehret et al. (1980a,b) used metabolic indicators to examine both circadian and ultradian rhythms in rats exposed to 8.2, 33, 66 or 100 kVm. They observed no effects due to exposure. Wilson et al. (1981, 1983) examined circadian rhythms in rats in a more direct fashion, measuring the cyclical

pineal production of indolamines and enzymes. A significant reduction in the normal nighttime rise of melatonin and biosynthetic enzymes was observed in rats exposed to either 1.5 or 40 kV/m. Furthermore, the change in pineal indole response occurred only after 3 weeks of chronic exposure (Anderson et al., 1982).

Nervous System. Many of the reported effects of electric-field exposure appear to be related to the nervous system. This is not unexpected since the nervous system provides the sensory input from external stimuli. Although prior investigations reported no effects in the morphology of the central nervous system (CNS) of rats and chicks (Phillips et al., 1978; Carter and Graves, 1975; Bankoske et al., 1976), a recent study in Sweden (Hansson, 1981a,b) found significant changes in cell structure in the cerebellum of rabbits exposed to 14 kV/m. Exposed animals had abnormal morphology of the endoplasmic reticulum and many lamellar bodies, particularly in Purkinje cells of the cerebellum. Effects have also been demonstrated in the nervous system function of rats. Jaffe et al. (1980) showed a statistically significant increase in the excitability of synapses in the superior cervical sympathetic ganglia of rats exposed to 100 kV/m. Although no effect on the peripheral nervous system was seen, neuromuscular function was altered by exposure. A slightly faster recovery from fatigue occurred in one type of muscle following exposure to electric fields (Jaffe et al., 1981). Additional work has recently been reported (R. Jaffe, personal communication) on the effect of electric-field exposure on somatosensory receptors in rats. This investigator has identified a subcutaneous "wide-field receptor" that is stimulated by the electric field.

Endocrinology. Many of the major hormones have been examined for effects of electric-field exposure, particularly in rats and mice (Phillips et al., 1979a). Possible effects have been observed in only three: corticosterone, testosterone and melatonin. Because corticosterone is produced by the body in response to stress, blood levels of the hormone are extremely sensitive to the method used in obtaining samples. Perhaps because of this sensitivity (rather than effects of electric-field exposure), five laboratories have reported conflicting results. Marino et al. (1976b) reported depressed serum corticosterone in rats exposed to 15 kV/m. Hackman and Graves (1981) reported a transient increase in steroid concentrations in mice at the onset of exposure to 25 and 50 kV/m. In contrast, corticosterone levels were not affected in dogs exposed to 15 kV/m (Gann 1976) or in rats exposed to 80 or 100 kV/m (Seto et al., 1982; Free et al., 1981). Lymangrover (1983) reported a threefold elevation in steroidogenic response of rat adrenal tissue exposed in vitro to 10 kV/m and treated with ACTH. No significant changes were observed, however, in tissue response when exposure was 5, 100 or 1000 kV/m. Serum testosterone levels were decreased from those of controls in rats exposed to 100 kV/m for 120 days but were not different from levels in controls in 30-day exposures (Free et al., 1981). Pineal melatonin levels were significantly reduced during the dark phase in rats exposed to 1.5 and 40 kV/m for 30 days (Wilson et al., 1981, 1983).

Bone Growth and Repair. In one report (McClanahan and Phillips, 1983), bone growth in rats did not appear to be affected by exposure to 100 kV/m. Two other studies (Marino et al., 1979a,b; McClanahan and Phillips, 1983) reported that bone-fracture repair was retarded in rats and mice exposed to 5 kV/m or 100 kV/m but not in animals exposed to very low (1-kV/m) field

strengths. McClanahan and Phillips (1983) suggest that exposure affects the rate of healing but not the strength of the healed bone.

Cardiovascular System and Blood Chemistry. Cardiovascular function has been assessed by measuring blood pressure and heart rate and by performing ECGs. Early studies reported, as possible effects of exposure, a decrease in heart rate and cardiac output in dogs exposed to 15 kV/m (Gann, 1976), and increased heart rates in chickens exposed to 80 kV/m (Carter and Graves, 1975). A more recent and comprehensive study in rats exposed to 100 kV/m showed no effect of exposure, even when the animals were subjected to cold stress (Hilton and Phillips, 1980). Cerretelli and Malaguti (1976) reported transient increases in blood pressure in dogs exposed to field strengths greater than 10 kV/m (50-Hz). Hilton and Phillips (1980) were unable to confirm a report by Blanchi et al. (1973) of changes in ECGs of animals exposed to 100 kV/m.

Serum chemistry appears to be unaffected by exposure. Several studies demostrated this, including those in rats at 100 V/m (Mathewson et al., 1977), in rats at 8 kV/m (Marino and Becker, 1977), and in rats at 100 kV/m (Ragan et al., 1979). Hematologic data, however, present a more confusing picture. White blood cell count was often elevated in exposed populations of mice and rats (Graves et al., 1979; Ragan et al., 1983). Fam (1980), who exposed mice to field strengths of 240 kV/m, found no differences in white or red cell count between exposed and sham-exposed male mice. However, he reported a significant decrease in white cells in exposed female mice. This study has not been replicated to assess the apparent contradiction with the other reports. The changes observed in white cell and, occasionally,

in red cell counts were not generally consistent across studies and may represent spurious findings. This was evident in the Pacific Northwest Laboratory (PNL) study (Ragan et al., 1983), where apparent sporadic effects were not statistically significant when the appropriate multivariate analyses were used to evaluate hematologic and serum chemistry parameters.

Immunology. In a comprehensive investigation of the humoral and cellular aspects of the immune system, Morris and Phillips (1982, 1983) and Morris and Ragan (1979) observed no effects of exposure at very low field strengths (150 to 250 V/m) in mice or rats. In chickens, used to study the influence of electric-field exposure on infectivity by a leukemogenic virus (Phillips et al., 1981), no effects of exposure were observed. Lyle et al. (1983), however, observed significant decrements in the cytolytic capacity of lymphocytes exposed to radiofrequency fields modulated at 60 Hz.

Fertility and Reproduction. Several studies have examined egg production and early development of chickens at low field strengths (Durfee et al., 1976; Kreuger et al., 1975; Bankoske et al., 1976). No effects of exposure were observed in hatchability, morphology or development of chicks. Kreuger et al. (1975), however, reported reduced egg production in hens exposed at 3.4 kV/m. At higher field strengths (100 kV/m) no effects of exposure were observed on the reproductive ability, fertility, or mortality of rats and mice (Sikov et al., 1979; Knickerbocker et al., 1967). Results at PNL have indicated that sows exposed for extended periods of time are reluctant to breed and have a significantly increased incidence of teratisms in their offspring (Phillips, 1981).

Growth and Development. Many experiments have been performed to examine bees, chicks, mice, rats, and swine for effects of exposure (100 V/m - 100 kV/m) on body weight. The majority of these studies (Mathewson et al., 1977; Kreuger et al., 1972; Greenberg et al., 1979; Graves et al., 1979; Bankoske et al., 1976; Phillips et al., 1979a, 1981; Fam, 1980) report no significant differences in growth between exposed and control populations. However, effects have been reported by Marino, who observed decreased body weight in rats and mice exposed to 5 and 15 kV/m (Marino et al., 1976a,b, 1980). Knickerbocker et al. (1967) also observed decreased body weight in male offspring of mice exposed at a very high field strength (160 kV/m). Hannson (1981a,b) reported a large (50%) decrease in the weight of rabbits exposed to 14 kV/m compared to unexposed controls. However, these rabbits were exposed out of doors, and he did not observe comparable growth stunting in laboratory-exposed animals. This discrepancy might result from an interaction between the electric field and the outdoor environmental conditions. Notable effects on development (as indicated above) have been seen in the study on the teratology of swine exposed for long durations to 30 kV/m (Phillips, 1981).

Mortality and Pathology. Studies by Moos (1964) and Phillips et al. (1979a) indicated no effect of either low (1.2-kV/m) or high (100-kV/m) field strengths on mortality rates in rats and mice. Again, results of studies by Marino et al. (1976a) differ: they report significant increases in mortality in mice exposed to 10 or 15 kV/m. Work by three other groups of investigators (Mathewson et al., 1977; Knickerbocker et al., 1967; Phillips et al., 1979a) shows no effect of electric-field exposure on tissue morphology of rats or mice.

Cellular and Membrane Studies. Several laboratories have examined the effect of electric fields on *in vitro* systems. Some obvious strengths of these studies are the large sample sizes available and the great degree of control over experimental variables. Also, these studies provide, better than whole-animal experiments, a fairly direct investigation of possible mechanisms of interaction between a biological system and the electric field. The most serious problems with *in vitro* experiments are those of dosimetry, and extrapolation. The dosimetric relationship between exposure in cellular systems and in whole animals is unclear, and extrapolation of results from the simpler systems to intact animals, particularly humans, is extremely tenuous.

Preliminary results of experiments using cultured Chinese hamster ovary (CHO) cells showed no effects of exposure to 3.7 V/m on cell viability, growth or mutation rate (Frazier et al., 1982). Cell-plating efficiency, however (presumably reflecting an alteration in the cell membrane), was reduced in cells exposed to 60-Hz fields greater than 0.7 V/m. A number of studies have been performed, at the same field strength, on slime mold (Marron et al., 1975; Goodman et al., 1976, 1979). After several months of exposure, frequency-dependent effects occurred in mitotic rate, cell respiration and protoplasmic streaming. Interestingly, these effects were observed with both electric field and magnetic fields, alone or in combination.

Neural tissue in culture has been used in several studies, particularly those focusing on the interaction of electric fields with the cell membrane. Wachtel (1979) and Sheppard et al. (1980) demonstrated that the excitability of pacemaker neurons in *Aplasia* is altered by field-induced extracellular

currents. Electrophysiologic data from mammalian brain slices indicate that a field of 0.1 V/m caused a potentiation of collective cell-firing in hippocampal neurons (Bawin et al., 1981).

An additional group of studies suggest that weak electric fields can affect biomolecular structure in quite specific ways. Several studies examined the "calcium efflux" from neural tissues exposed in vitro to low-frequency as well as to modulated-radiofrequency electric fields. Effects were apparently restricted to certain "windows" in frequency and field strengths. Bawin et al. (1975, 1976) and Blackman et al. (1979, 1983, 1985) reported significant alterations in calcium exchange from cat and chick brain tissues exposed to fields as low as 100 V/m. Since calcium plays a key neuroregulatory role in many membrane processes, such field-induced changes in calcium exchange may result in significant changes in brain function. The occurrence of frequency and power windows, however, makes interpretation of the data difficult.

Mutagenesis. No effects have been observed which might suggest an effect of electric-field exposure on mutagenesis (Mittler, 1972; Phillips et al., 1979a; Frazier, 1982).

DISCUSSION

Numerous studies have been initiated to determine to what extent the electrical environment produced by power-line transmission poses a health hazard to living organisms (particularly to humans). The biological effects reported in many of the experiments have not yet confirmed any pathological effects, even after prolonged exposures to high-strength (100-kV/m) fields.

Areas in which effects have been demonstrated appear to be primarily associated with the nervous system: altered neuronal excitability, altered circadian levels of pineal hormones, behavioral aversion to or preference for the field, and altered locomotor activity in the field (often transient). In the intact animal, it is not yet known whether these and other putative effects are due to a direct interaction of the electric field with tissue or to an indirect interaction, e.g., a physiological response due to detection and/or sensory stimulation by the field. The nature of the physical mechanisms involved in field-induced effects is obscure, and such knowledge is one of the urgent goals of current research.

Results to date have demonstrated various biological effects in specific species exposed in the laboratory to a wide range of field strengths. The extrapolation of specific effects that occur under controlled laboratory conditions to a general assessment of the health risk of a human population exposed to electric fields is very tenuous. At least four considerations are critical to implement such an extrapolation with validity: 1) the relationship of specific laboratory conditions to the power-line environment; 2) the relevance of effects in laboratory animals to other species, particularly humans; 3) dosimetric considerations, including scaling between species; and 4) an evaluation of the biological consequences of observed effects.

Many of the experiments reviewed in this report were designed to study the effects of electric fields under laboratory conditions. In most cases, field strengths that were employed corresponded to those characteristic of power lines, but factors other than the electric field may have affected experimental results. Such factors, e.g., ozone, ions, spark discharge,

audible noise, etc., can produce biological effects and must be recognized and controlled to determine whether the electric field is actually the agent responsible for observed effects.

Any extrapolation of effects from one species to another depends on the mechanism by which the field exerts its influence on the biological system. This requires a knowledge of the biological structures and functions involved, as well as dosimetric scaling of exposure from the test animal to another species.

Perhaps most difficult is the question of when the occurrence of a "biological effect" constitutes a health hazard. Specific answers may be forthcoming; however, experimental results to date show no clear implications of health risks to humans exposed to 60-Hz electric fields.

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